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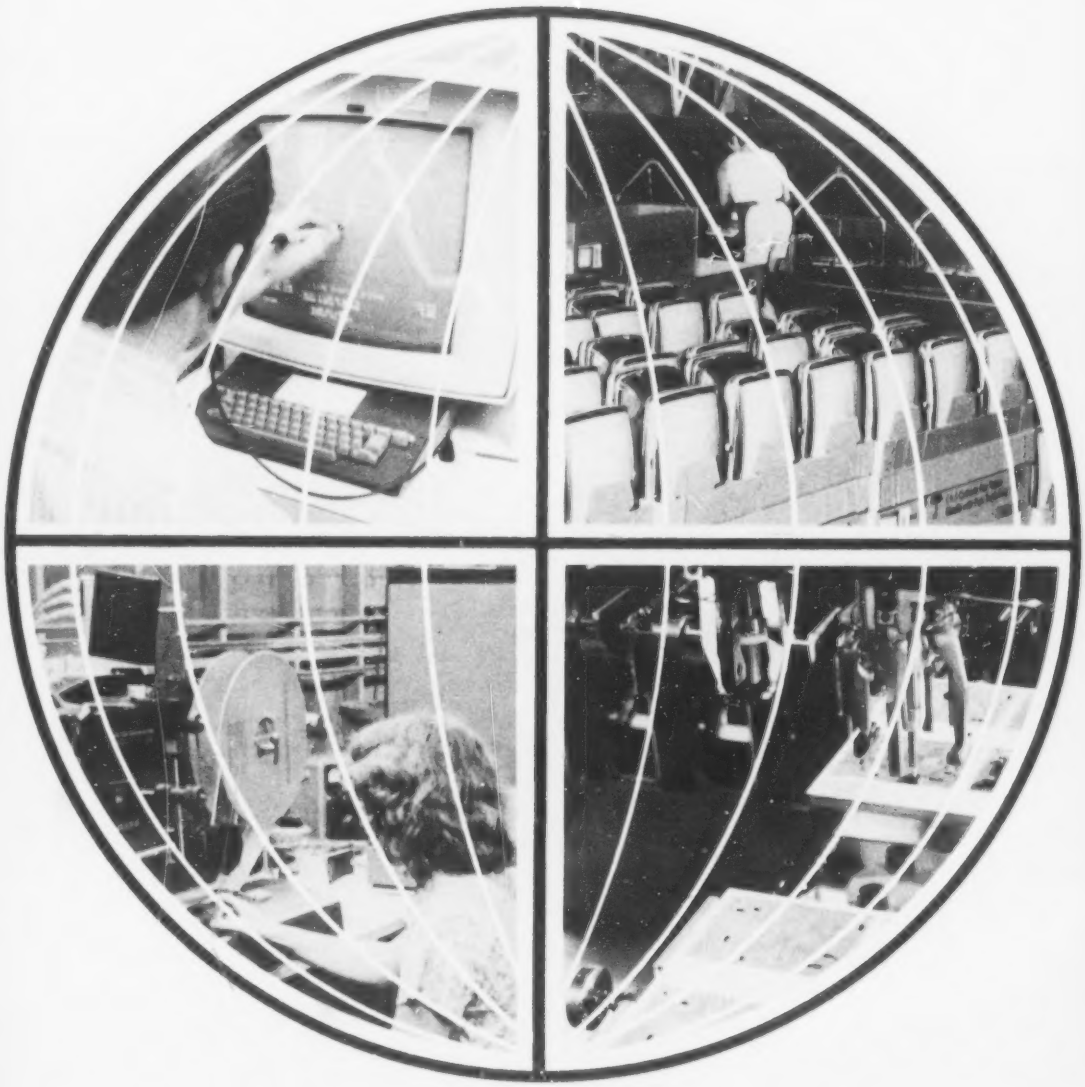
International Competitiveness In Electronics



Summary

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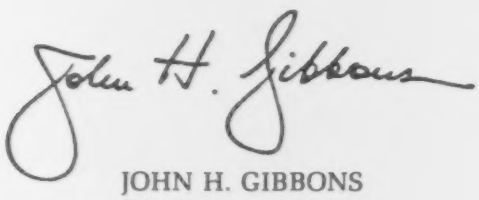
Foreword

This assessment, requested by the Senate Committee on Commerce, Science, and Transportation, the House Committee on Ways and Means, and the Joint Economic Committee, completes a series of three reports on the competitiveness of U.S. industries. The series began with *Technology and Steel Industry Competitiveness* and continued with *U.S. Industrial Competitiveness: A Comparison of Steel, Electronics, and Automobiles.*

Today, the subject of international competitiveness has more visibility among the general public than ever before. It has emerged as one of the primary economic issues facing Congress. Debates over "reindustrialization" and "industrial policy" beginning several years ago have been renewed. This assessment continues OTA's exploration of the meaning of industrial policy in the U.S. context, while also examining the industrial policies of several of our economic rivals.

Electronics virtually defines "high technology" in the 1980's. This assessment sets the characteristics of the technology itself—a technology already of such ubiquity that microprocessors and computers outnumber people in the United States—alongside other forces that exert major influences over international competitiveness. These factors range from human resources and costs of capital to the priorities that corporate managers place on manufacturing technologies and the quality of their products. The report concludes by outlining five options for a U.S. industrial policy, drawing on electronics for examples of past and prospective impacts, as well as on OTA's previous studies of the steel and automobile industries.

OTA is grateful for the assistance of the advisory panel for this assessment, as well as for the help provided by many individuals in other parts of the Federal Government. OTA assumes full responsibility for the report.



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International Competitiveness in Electronics Project Staff

Lionel S. Johns, *Assistant Director, OTA*
Energy, Materials, and International Security Division

Peter Sharfman, *Program Manager*
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John A. Alic, *Project Director*
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Contributors

Robert Fisher* Phillip Otterness*
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Administrative Staff

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Contractors

L. W. Borgman & Co.
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Washington, D.C.

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International Competitiveness in Electronics

Is the United States in danger of losing, to the Japanese or others, in the race to develop new high-technology electronics products—fifth-generation computers, high-density integrated circuits, pocket televisions? Does the decline of the American consumer electronics industry prefigure that of semiconductors or computers? Is U.S. standing in world markets deteriorating because of poor management, slipshod Government policymaking, overregulation of business? Will work in automobile production or heavy industry be permanently replaced by high-technology jobs fewer in number and paying wages at half the level of the $15 to $20 per hour earned by auto or steelworkers? To what extent can electronics stand for other technology-based U.S. industries? Which policies of the Federal Government are most crucial to the international competitiveness of industries like electronics? Does the United States need a more coherent industrial policy?

These questions and others like them are addressed in the full report, which covers three portions of the industry: consumer products (primarily color television); semiconductor devices such as integrated circuits; and computers. The focus of the full report is the United States, but considerable attention goes to the electronics industries of Western Europe and Japan, as well as several of the newly industrializing countries.

Electronics in total employs more than a million and a half Americans; 1982 sales exceeded $125 billion—roughly one-fifth of total U.S. durable goods output—and have been growing at nearly 15 percent per year; the sector is an export leader, with a surplus of about $3 billion on a total trade volume of nearly $50 billion. The industry's products feed many other portions of the U.S. economy. Not only does the Nation's defense depend heavily on electronic technologies, but both manufacturing and service industries—ranging from the production of numerically controlled machine tools to banking and insurance—use electronic products both directly and indirectly.

The competitiveness of firms and industries refers to the ability of firms in one country to design, develop, manufacture, and market their products in competition with firms and industries in other countries. At several points below, shares of the U.S. market or of world markets are used as examples of trends in international competitiveness; in fact, however, competitiveness is a more subtle concept. While market share is one possible indicator, it is only indirectly related to competitiveness.

How an industry will fare in international competition depends on factors ranging from technology itself, to industrial policies pursued by national governments, to the human resources—technicians to upper-level managers—available in a given country. In some cases, competitiveness is primarily a function of prices, hence manufacturing costs—themselves determined by wage rates, labor productivities, the design of both products and manufacturing processes. This is the case in consumer electronics. In higher technology portions of the industry, one firm may be able to offer products that are beyond the technical capabilities of its rivals—e.g., high-density integrated circuits, advanced computer software. Where this is true, costs are less important.

From the Federal perspective, shifts in the international competitiveness of American industries have ramifications far beyond matters of trade balances and foreign economic policy, even military security. The competitive standing of a nation's industries will determine quite directly its gross domestic product, and therefore the standard of living of its citizens.

The linkage between competitiveness and employment—in the aggregate, in particular sectors, or in particular occupational categories—is much looser. Industries can rise in competitiveness while declining in employment—the case in the U.S. textile industry in recent years. In other cases, competitiveness may remain high, output may expand, but domestic employment may grow relatively slowly compared to output; this has been the case in both the U.S. semiconductor and computer industries. Similarly, domestic employment is only loosely related to trends in foreign investment or to government policies directed at controlling flows of imported goods; trade protection has helped the employment picture in the U.S. consumer electronics industry no more than it has in the steel industry or the automobile industry.

While the competitiveness of a given sector of the U.S. economy depends on both domestic and international economic forces, the domestic context—e.g., people and institutions here, not overseas—generally carries the most weight in determining *which* industries will grow in competitiveness, which decline. As a result, *public policies with domestic objectives exert the most influence over trends in international competitiveness.* These are matters of industrial policy. OTA uses this term in a neutral sense to refer to the body of regulations, laws, and other policy instruments that affect the activities of industry and the resources, including human capital, that the Nation's economy depends on. The United States has not in the past had a self-conscious industrial policy, in part because it had no need for one. The lesson of the U.S. electronics industry, along with industries like steel and automobiles that OTA has examined previously, is that future international competitiveness may well depend on a more coherent and consistent approach by the Federal Government to matters of industrial policy.

Principal Findings

U.S. Competitiveness in Electronics

1. *Electronics remains a leader among American industries.* High-technology firms—including those making microelectronic devices like integrated circuits and complex electronic systems such as computers—continue to be leading exporters, second to none in technology as well as most measures of commercial success. Although the Nation's imports of semiconductor products exceeded its exports for the first time in 1982 (by $160 million out of $3.8 billion in imports) more than three-quarters of these imports were shipments by American-owned firms; computer exports ($9 billion in 1982) far exceed imports.

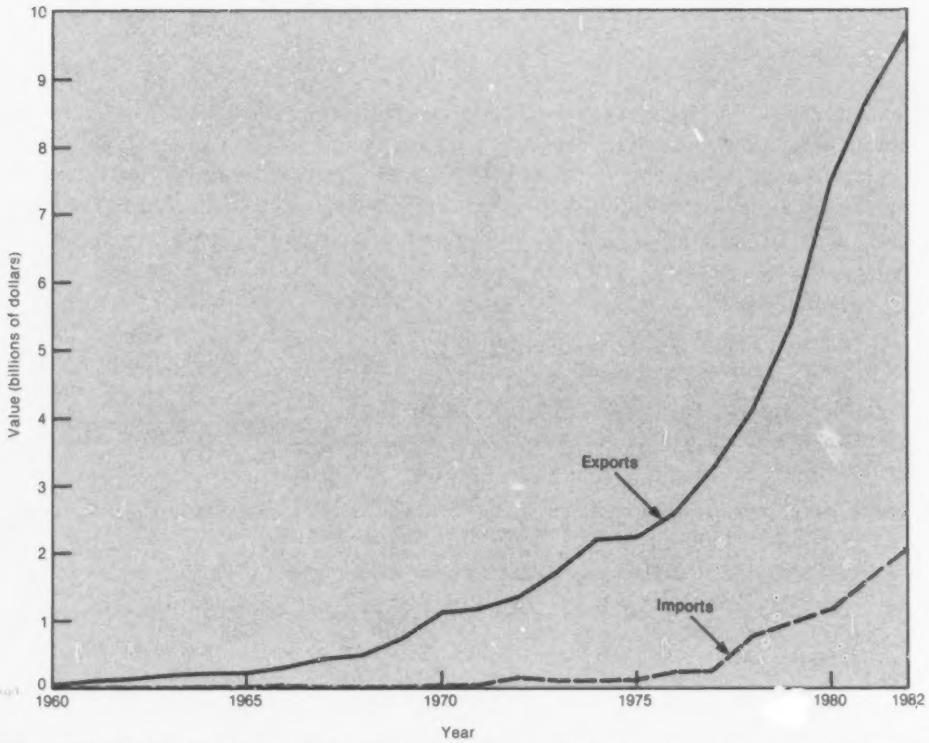
This is not to say that there is little cause for concern, or that the waves of publicity given the progress made by Japan's electronics manufacturers over the past few years have in all cases been overdramatized. If the U.S. electronics industry is still strong when compared to other domestic industries, its margins with respect to electronics industries in other nations have shrunk, in some cases vanished. Moreover, the Japanese electronics industry is one of the most productive in that nation's economy; this high standing relative to other domestic sectors is a major reason for the export strength of Japan's electronics manufacturers. In almost all categories of electronics products—office copiers and typewriters, microelectronics, communications equipment and consumer goods—the U.S.-Japan trade balance is strongly negative (see ch. 4 of the full report).

2. Just as the competitive positions of a nation's industries will differ, with some rising and others declining, so competitive positions *within* an industry like electronics will vary. Likewise, within one portion of the industry, such as color television manufacturing, some firms will at any given time be more competitive than others.

Within the U.S. electronics industry, *competitiveness in consumer products has declined precipitously since the 1960's.* The Nation now imports many of its consumer electronic products, while more than 10 foreign-owned firms assemble and market television sets within the United States. In contrast, *there are few signs of slackening competitiveness in the manufacture of computers,* although the U.S. lead in technology is certainly less than even half a dozen years ago. *American-owned firms making and selling semiconductor devices have faced increasingly intense competition from Japanese manufacturers,* again primarily over the last half-dozen years; although they have lost market share both at home and abroad in some key products—e.g., computer memory chips—*their overall position remains strong.*

3. *It is not realistic to expect that American semiconductor and computer firms will, in the near future and in the absence of cataclysmic changes in other parts of the world, return to the preeminent positions*

U.S. Exports and Imports of Computers and Equipment



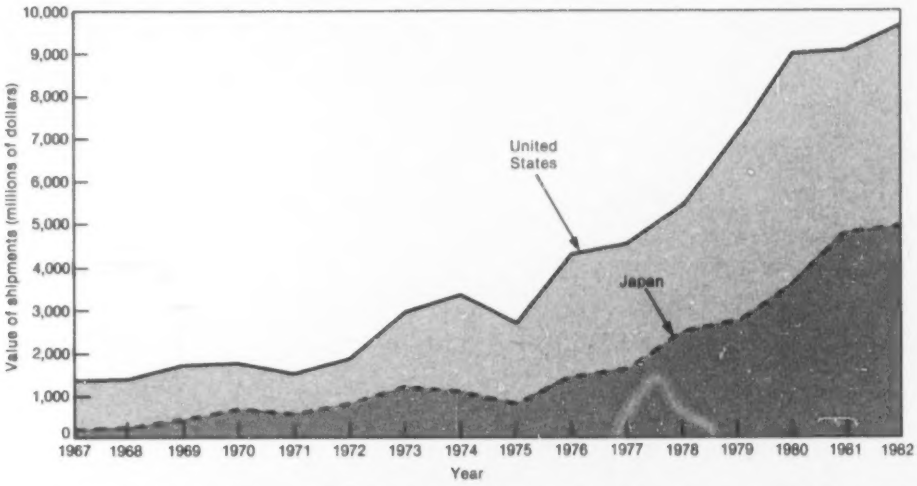
SOURCES: ***1960-66***—*Gaps in Technology: Electronic Computers* (Paris: Organization for Economic Cooperation and Development, 1969), p. 50.
1967-81—1972, 1977, 1980, 1982 editions, *U.S. Industrial Outlook,* Department of Commerce.
1982—U.S. Department of Commerce, Bureau of Industrial Economics.

they held at the beginning of the 1970's. Nor can the United States expect to achieve the technological and commercial leads of earlier years in other high-technology industries. The capabilities of other countries have improved; foreign electronics industries have risen within their own economies; international economic conditions have changed.

4. *The United States can continue to be highly competitive in electronics and other technologically driven industries,* with U.S. firms remaining leaders in innovation, in international trade, and in sales and profits at home and abroad. *Not only is this possible, it is necessary* if the United States is to maintain its standard of living, its military security, and if the U.S. economy is to provide well-paying and satisfying jobs for the Nation's labor force. Electronics is indispensable to a broad range of manufacturing and service functions, from computer-aided design of the structures of office buildings to the switching of the telephones within those buildings.

5. *Congress could take the initiative in devising programs that would actively support the electronics industry,* and others of comparable importance. The first requisite is broad national agreement on the role

Semiconductor Production in the United States and Japan



SOURCES: ***United States—1967-76—A Report on the U.S. Semiconductor Industry*** (Washington, D.C.: Department of Commerce, September 1979), p. 39.
1977-80—Summary of Trade and Tariff Information: Semiconductors (Washington, D.C.: U.S. International Trade Commission Publication 841, Control No. 6-5-22, July 1982), p. 26.
1981, 1982—1983 U.S. Industrial Outlook (Washington, D.C.: U.S. Department of Commerce, January 1983), p. 29-7.
Japan—1967-80—Japan Fact Book '80 (Tokyo: Dempa Publications, Inc., 1980), p. 188; *Japan Electronics Almanac 1982* (Tokyo: Dempa Publications, Inc., 1982), pp. 149, 178.
1981, 1982—In-Stat Electronics Reports Feb. 21, 1983, p. 5.

of high-technology sectors like electronics as a driving force for future economic growth, a greater degree of consensus on where the U.S. economy is now heading and where it *should* head. The second is better understanding of how particular pieces of legislation affect the competitiveness of American industry, which in turn requires developing the capability of the Federal Government for analyzing the sources of competitive strength.

The Role of Technology

1. One way to establish a competitive advantage in an industry like electronics is through superior technology. *Better process technology—e.g., automation—can help reduce costs.* For similar products, lower manufacturing costs permit lower selling prices, hence a more competitive product. Alternatively, higher profits may be possible, which can help finance further improvements. Production technologies are particularly important in consumer electronics and semiconductors, less so for large computers.

2. *Superior product technologies may command premium prices in the marketplace, making manufacturing costs less significant.* Product features—ranging from appearance to quantifiable characteristics such as the performance of a computer system in running "benchmark" programs—can contribute to competitive advantage; in high-technol-

ogy fields as in low, product differentiation and astute marketing can be important.

Understanding customer wants and needs is vital to designing successful products; integrated circuits that are functionally similar, perhaps even interchangeable, may be differentiated through subtle variations in performance; advertising strategies can be built around claims of high quality or rapid delivery; a broad array of alternate source suppliers may reassure prospective purchasers. Manufacturers of computers and peripherals devote considerable effort to industrial design and human factors engineering; ease of use is vital in selling computer systems to first-time customers.

Rapid technical change creates much more scope for product technology as a competitive weapon in microelectronics and computers than in consumer electronics. For many years, American semiconductor and computer manufacturers prospered by offering products that firms elsewhere in the world could not design or build.

Industrial Policy

1. OTA takes industrial policy to be a neutral term referring to the group of Federal policies that affect competitiveness, productivity, and economic efficiency—sometimes directly, sometimes through influences on business decisions or on individuals. Industries rise and fall in international competition for many reasons. Seldom can single causes be found—more seldom yet simple, straightforward policy remedies. Plainly, *industrial policy offers no quick fixes for the dilemmas of the U.S. consumer electronics industry, nor any sure prescriptions that can guarantee the future competitiveness of our microelectronics or computer sectors.* Just as plainly, competitiveness in electronics—and in other U.S. high-technology industries—will depend on factors including:

- capable people, hence on Federal policies dealing with education and training;
- capital for new business startups and for expansion, hence on macroeconomic and tax policies;
- open markets for American products, hence on foreign economic policy; and
- the research base that supports domestic firms, hence on Federal technology and science policy.

The job of industrial policy is to evaluate, link, and coordinate the many Federal efforts that deal with such concerns.

2. *While international competitiveness is firmly rooted in the efforts of private companies, public policies set many of the rules of the game.* In the United States and in other parts of the world, business enterprises compete in an environment shaped to considerable extent by government industrial policies (including elements of fiscal, monetary, tax, manpower, trade, and regulatory policies).

Foreign governments are experimenting with industrial policies intended to aid and support their own electronics industries; virtually all industrialized and industrializing nations single out electronics for special treatment. American firms seeking to export or to manufacture overseas must contend with economic and social policies of host governments that are more complex and sophisticated than in the past. Rather than outright protectionism or other forms of overt discrimination against foreign firms, host governments now adopt indirect subsidies for their own industries—tax incentives, capital allocations, funding for commercially oriented research and development (R&D). At the same time, governments bargain with foreign multinationals using carrots and sticks such as investment incentives and performance requirements while seeking to acquire jobs and technology, or to improve their balance of payments.

3. Although a well-designed and supportive industrial policy is not, by itself, sufficient to build competitiveness in a given sector of a nation's economy, government policies can, under some circumstances, tip the balance. *The United States can expect no more than very limited success in negotiations with other nations aimed at minimizing the impacts of those countries' industrial policies.*

For this and other reasons, a "business-as-usual" approach is unlikely to prove sufficient to the task of maintaining U.S. competitiveness in electronics. *Better prospects for strengthening the U.S. position would come with the adoption of more effective industrial policies of our own.* The American electronics industry faces only a few *major* problems, mostly in the trade arena, that are directly susceptible to Government remedy. On the other hand, Federal agencies could support the industry —directly and indirectly—in many ways. Few of these would have much visibility. By the same token, they would not necessarily cost much. Consistent and careful attention to the many smaller matters that affect competitiveness—diffusion of technology within the United States, tax treatment of equipment contributions to universities, the antitrust environment for joint R&D, long-term basic research—are the necessary ingredients in a more coherent and productive industrial policy. A supercomputer project, to take a current example, may be glamorous as well as desirable in itself, but is no substitute.

4. The choice of policy tools, and the design of individual measures, depend on overall objectives; an industrial policy is the sum of many parts that can be put together in different ways. Should Congress wish to pursue a more focused industrial policy for the United States, it could choose from among five broad alternatives:

- A protective strategy aimed at *preserving the domestic market base for U.S. industries,* along with preservation of existing jobs and job opportunities.
- *Protection and/or support for a limited number of industries judged critical* for the U.S. economy or, more narrowly, for national security.

- *Support for the technological base and institutional infrastructure* that underlie American industries, with particular attention to structural adjustment (e.g., labor force retraining and mobility).
- *Promotion of the global competitiveness of U.S. firms and industries* by encouraging exports and open competition in domestic as well as international markets.
- *Deferral where possible to the private sector* when choices concerning industrial development are to be made.

While these five approaches to industrial policy, discussed in chapter 12 of the full report, are certainly not mutually exclusive, they represent distinctly different thrusts, implying different mixes of policy instruments as well as different goals.

What would be the implications of a decision to pursue a more coherent industrial policy in the United States? First and foremost, that to automatically equate "industrial policy" with a greater degree of Government involvement in the economy is to view the matter from an arbitrarily narrow perspective. *Industrial policy does not have to run counter to efforts to "get Government off the backs of business." Rather, it should be construed as an effort to make the inevitable—indeed oftentimes desirable and necessary—Federal involvement a more consistently productive one.* It implies an effort to develop, both politically and institutionally, Government policies toward industry that:

- explicitly consider impacts on competitiveness and economic efficiency;
- seek to treat the problems and opportunities of particular industries in the context of the economy as a whole, rather than in isolation; and,
- do a better job of relating policy tools to policy objectives.

Policy Concerns in Electronics

Among the elements of industrial policy, the following are vital for the continuing competitiveness of the U.S. electronics industry. They might have rather different places, and be addressed in different ways, under each of the alternatives listed above.

1. High-quality *education and training* (including retraining) for engineers, technicians, and other skilled workers.

More than anything else, the competitive position of the United States in high technology has been built on the human resources available here. A renewed Federal commitment to education and training seems called for (see chs. 8 and 9 of the full report). Engineering enrollments running at record levels have swamped the resources available in colleges and universities; even so, the United States graduated but 63,000 engineers in 1981 compared to 75,000 in Japan.

U.S. electronics firms have faced serious problems in finding adequate numbers of engineers, as well as technicians and service person-

nel with needed skills and aptitudes. Inadequate resources in U.S. engineering schools are harming the quality of education as well as constraining the numbers of new graduates. Training and retraining for technicians and paraprofessionals varies widely in quality and appropriateness to emerging needs. Many people in the United States emerge from high school quite unprepared to work in technology-based industries.

Despite fluctuations in supply and demand over the years, engineers in principle comprise one of the most employable occupational groups in the labor force; it is hard to imagine an "oversupply" of engineers or of people with good technical training of any of a wide variety of types in an economy like that of the United States, provided that people are willing and able to shift jobs according to demand within the economy and organizations are willing to help them do so.

2. A strong *technological base*—stemming from basic research and applied R&D with long-term objectives, including the diffusion of results, in fields such as solid-state electronics, optical devices, communications technologies, computer-aided design of circuits and systems, and computer software.

The Federal Government could not only continue to fund basic research, it could establish new mechanisms for diffusing the results of R&D to the private sector, experiment with the support of commercially oriented (rather than military) research, and strengthen tax incentives and other encouragements for successful innovators.

3. *Economic adjustment* policies that smooth flows of capital and labor within the economy, aiding growing firms in their efforts to compete while providing well-paying jobs for the domestic labor force.

Structural change is a fact of life in American industries, driven by the currents of an increasingly open international economy (see chs. 4 and 5 of the full report), as well as by technological change (ch. 3). Corporations, cities and regions, and people must adjust to changes, many of which are outside their control. Federal attention to maximizing the positive effectives of change—e.g., stimulating growth industries —while ameliorating the negative impacts, could be one of the central elements in a more coherent industrial policy for the United States. Policy initiatives aimed at personnel mobility—whether geographic, inter-industry, or within organizations—are one example.

4. Adequate supplies of *investment capital* for new startups as well as rapidly expanding established firms.

As discussed in chapter 7 of the full report, venture capital markets in the United States function well, although cyclic downturns are likely to recur and risk capital is often hard to find at early stages of technology development.

Rapidly growing companies, particularly in the semiconductor industry, do face severe financial pressures. These stem from increasing capital intensity, due both to higher R&D expenses and to production

equipment that has gone up in cost by an order of magnitude over the past decade, coupled with the preference of American managers to finance expansion from internally generated funds. Tax policies have a major influence over sources of financing and risk absorption.

While the advantages are not as great as sometimes implied, large diversified electronics companies in Japan, and perhaps in some Western European countries, do benefit from real (i.e., inflation-adjusted) costs of capital that are somewhat lower than for merchant semiconductor firms in the United States. By themselves, these differences—matters of a few percentage points—are not enough to weigh heavily in the competitive balance. Constraints on *rates* of capital spending—due in part to the preference of American firms for internal financing—are more likely to be a drag on the competitive abilities of U.S. manufacturers. These and other factors, primarily expectations concerning inflation, tilt the investment decisions of American managers toward the shorter term.

5. An *international trading environment* that places U.S. firms on a more-or-less equal footing with their competitors in other countries, including those that have well-developed industrial policies intended to protect or promote domestic manufacturers.

As discussed in chapter 11 of the report, the framework for international trade that emerged in the postwar era is being overrun by events. The thrust of industrial policies in many nations is toward indirect supports with effects on prices and on competitiveness that cannot be quantitatively assessed (see ch. 10). Japanese industrial policy, for instance, works in part by breaking bottlenecks; the VLSI project of the 1970's helped train Japanese engineers, transferred design and processing know-how to industry, rallied public support behind the structural shifts that were leading Japan toward an "information economy" (or at least helped diffuse counterpressures by those disadvantaged by such shifts). The goals of the heavily publicized fifth-generation computer project are similar. When many of the impacts of industrial policies are intangible, how do we countervail them? Over at least the rest of the decade, U.S. trade negotiators can expect to grapple with such issues. The prerequisite is an analytical capability by the Federal Government adequate for understanding the ways in which public policies—here and elsewhere—affect international competitiveness.

American electronics firms, particularly manufacturers of semiconductors and computers, may also need the continuing support of the U.S. Government, via both bilateral and multilateral negotiations, in securing access on reasonable terms to foreign markets—for exports and for direct investment—if they are to maintain their competitive position. Only by competing aggressively all over the world, taking advantage of scale economies and new opportunities, can American firms expect to share fully in the growth and expansion that will characterize this industry into the next century. As an example, semiconductor sales in Japan already exceed those in all of Western Europe by more than

half; *U.S. firms need access to Japan's market comparable to that enjoyed by Japanese suppliers here.*

Regardless of the overall approach and direction of U.S. industrial policy, Congress could act in support of objectives such as those outlined above.

The Competitive Position of the U.S. Electronics Industry

Consumer Electronics

1. American firms making radios, TVs, and audio products such as stereo receivers and tape recorders have been under severe competitive pressures for years; many have failed or left the market. Few radios or black-and-white TVs are made in the United States. No video cassette recorders are manufactured here. Color television production has become largely an assembly operation, heavily dependent on imported components—whether the parent firm is American-owned (RCA, Zenith, GE) or foreign-owned (Sony, Quasar, Magnavox). *In television manufacture especially, the policies of the Federal Government have contributed to the plight of the industry.* Dumping complaints against importers going back to 1968 have never been fully resolved. An industry legally entitled to trade protection has not received it.

2. Nonetheless, trade practices illegal under U.S. law have been only one factor in the declining competitiveness of the American consumer electronics industry. More fundamentally, competitive advantages have shifted to other parts of the world—first Japan, now newly industrializing countries like Taiwan and South Korea. These countries have mastered the technological requirements for mass-producing consumer products such as TV sets. They have lower labor costs than the United States, an adequate corps of skilled workers and engineers, supportive government industrial policies, and astute corporate managements.

U.S. Sales and Imports of Selected Consumer Electronic Products, 1982

	U.S. sales (millions of dollars)	Imports (millions of dollars)	Import penetration (percent)[a]
Color television	$4,253	$546	12.8%
Black-and-white TV	507	344	67.9
Video cassette recorders	1,303	1,032	100.0[a]
Home and auto radios[b]	1,579	1,207	76.4
Stereo systems[c]	1,754	1,342	76.5
	$9,396	$4,471	47.6%

[a]Because many items imported in a given year are not sold until the following year, dividing imports during a given calendar year by sales in that same year may give only a rough indication of import penetration; for instance, *all* video cassette recorders sold in the United States are imported even though 1982 sales figures exceed 1982 import figures.
[b]Including auto tape players.
[c]Including audio tape units and other component equipment.

SOURCE: *Electronic Market Data Book 1983* (Washington, D.C.: Electronic Industries Association, 1983), pp. 6, 19, 31.

American firms have been reduced to a reactive posture; they have lost the lead in product design and development while moving manufacturing operations to foreign countries in order to keep their costs competitive. American *products* in consumer electronics—e.g., color television receivers—continue to be competitive in performance, quality, and reliability, but they are no better than imports. *The consumer electronics market is highly price-competitive; without advantages in technology or product features, American manufacturers will be hard-pressed to keep up with their foreign-based competitors.* While U.S. firms may continue to innovate and to be leaders in consumer products aimed at specialized market niches—computer games have been a recent example—broadly speaking, product leadership has been lost. At least in the short term, prospects for taking the lead in new generations of high valued-added mass-market products seem slim.

3. The rise of foreign firms together with protracted trade disputes have contributed to a major shift in the structure of the U.S. consumer electronics industry. The number of firms has not changed greatly since the 1960's; but while once there were 16 or 17 American-owned manufacturers of TVs, today only 4 of 15 with plants in the United States have headquarters here. Still, *the market shares of the traditional U.S. leaders—Zenith and RCA—have not changed much;* together these two companies continue to hold about 40 percent of the U.S. color TV market. It is the weaker American manufacturers that have succumbed.

4. At the same time foreign enterprises were investing in assembly plants in the United States, American-owned firms were transferring labor-intensive manufacturing operations to low-wage offshore locations. In general, final assembly for the U.S. market remains here, with subassembly in Mexico and the Far East. These moves were driven by foreign competition. U.S. color TV manufacturers felt they had little option but to move production abroad if they were to cut costs and meet their competitor's prices.

Offshore production substitutes quite directly for jobs in the United States. Nonetheless, if American firms had *not* moved offshore, it is quite possible that they would have lost even more ground to foreign-based competition, with yet more jobs lost over the longer term. In most cases, *transfers of production overseas have net impacts on U.S. employment and on the U.S. economy that appear relatively small; improvements in labor productivity, for example—also driven by foreign competition—have been at least as important as a cause of employment declines in television manufacturing.* Needless to say, the impacts on individuals and communities where job losses concentrate are often severe and long-lasting; in 10 years the production work force in consumer electronics has been cut by more than 40 percent, from 85,000 to 50,000.

5. Beginning near the end of the 1970's, Orderly Marketing Agreements (OMAs) limited imports of color TVs while encouraging foreign firms to produce here. The result was to equalize the terms of com-

petition and to moderate employment declines in the United States. Otherwise, the OMAs did little to help the U.S. industry rebuild its competitive strength.

In this regard, U.S. experience with OMAs restricting color TV imports has paralleled other cases of import quotas, for instance in the steel industry. Although the ostensible purpose may be to give domestic firms time to restructure and adjust to changing competitive circumstances, in most cases *protected industries continue to react to pressures from abroad rather than taking strong positive steps of their own;* the notion that a respite from import competition will, by itself, help corporations restore their competitiveness gets little support from events in color television.

Semiconductors

1. *U.S. manufacturers of semiconductor products such as integrated circuits remain highly competitive in markets all over the world.* American-owned merchant firms—those that produce for the open market—are leaders in circuit design and process technology. While their share of world sales has changed little over the past few years, with U.S. firms and their subsidiaries still accounting for about 70 percent of worldwide output of integrated circuits, Japanese manufacturers have been catching up in technology. Nonetheless, U.S. companies have the capability to maintain their competitiveness in most world markets. The inroads made by Japanese suppliers of commodity-like chips, notably random access memories (RAMs), portend stronger competition in other types of microelectronic devices but do not translate automatically into advantages for products such as logic chips or microprocessor families. There is no reason to expect a loss of competitiveness in advanced microelectronic products paralleling that in consumer electronics.

Although foreign manufacturers may sometimes have advantages—e.g., supportive government industrial policies, as in Japan or Western Europe—the U.S. merchant firms have their own strengths. Among these are the ability to rapidly develop and commercialize new technologies, to anticipate and design for shifting customer needs, and to adapt to changing realities of international competition by entering into joint venture and technology transfer agreements with both domestic and foreign firms when this is advantageous.

2. The *structure* of the merchant portion of the U.S. semiconductor industry is changing. A number of well-established semiconductor firms founded during the 1960's or early 1970's have been acquired by larger, diversified enterprises, either American- or foreign-owned. In part, these structural shifts are associated with a trend toward captive production by end-product manufacturers.

Companies that design and build systems ranging from computers and communications networks to automobiles increasingly see needs for internal capability in the design, development, and manufacture

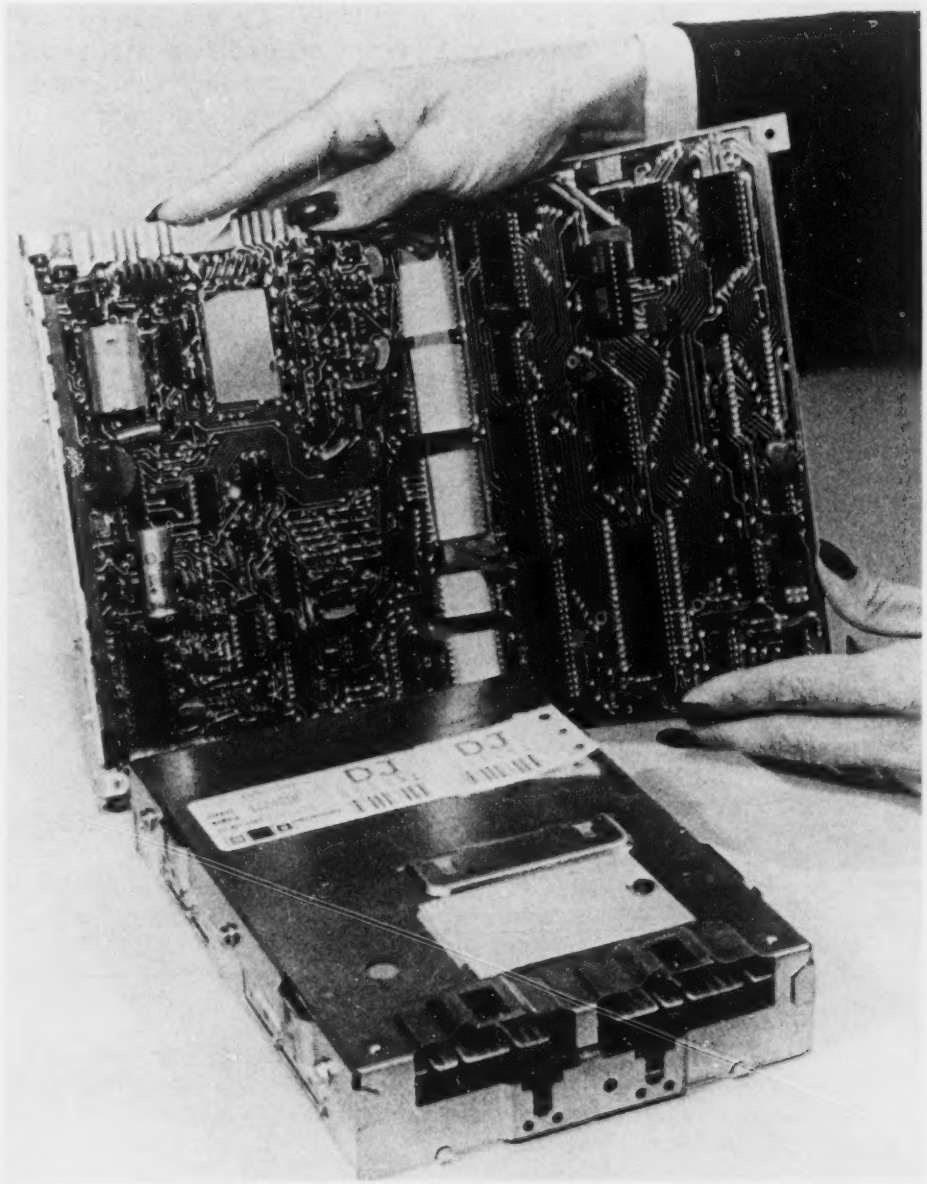


Photo credit: General Motors

Microcomputer for controlling an automobile engine

of state-of-the-art microelectronic devices. *The acquisition of merchant semiconductor firms by larger corporations is a predictable trend in the evolution of the industry.*

3. At the same time that relatively mature companies like Intersil—purchased during 1981 by General Electric—are being acquired, *new entrants continue to repopulate the merchant semiconductor industry.* While the downturn in venture capital markets during the middle and

late 1970's virtually halted start-ups, new firms are again being established. Since 1980, several dozen small firms producing custom integrated circuits, gate arrays, specialized memory chips, and other niche products have entered the industry. Aiming at portions of the market where the knowledge and expertise of their founders can be brought to bear, some of these start-ups will be successful and expand, some will remain small, others will be acquired by larger enterprises.

4. *Captive manufacturers of semiconductor devices make vital contributions to U.S. competitiveness.* Such companies include IBM, the largest producer of semiconductors in the world, and Western Electric, which moved into the merchant market in 1983—an action made possible by the settlement of the Government's antitrust suit against AT&T—as well as a number of aerospace and defense contractors. Companies that produce for internal use not only provide a major part of the technological foundations for microelectronics, they spawn start-ups and give training and experience to people who later move to other companies.

5. *Just as important for continuing international competitiveness are firms that design, develop, and build production equipment* for applications ranging from annealing silicon wafers to automated testing and assembly.

While the United States maintains the lead among open-market suppliers of many types of processing equipment, notably in lithography, other countries are catching up. Government-sponsored R&D in Japan has focused on production equipment.

6. R&D—particularly that with relatively long-term payoffs—will remain a critical force in support of U.S. semiconductor firms. In the past, much of the technology base has come from larger firms such as IBM and AT&T. Government support for research has not been significant in recent years, although the Very High-Speed Integrated Circuit program of the Defense Department will have commercial spinoffs.

The U.S. semiconductor industry can no longer rely on past approaches to R&D and technology development. The industry recognizes the changing situation, and is developing new mechanisms for strengthening its technical foundations; these include closer interactions with universities, along with joint ventures and cooperative research efforts. *Congress and the Federal Government could actively support and encourage both basic and applied research with longer run payoffs.* This is one of the surest ways of supporting continued U.S. competitiveness in microelectronics.

Computers

1. American manufacturers of digital computers have dominated world markets for many years. Much as U.S. semiconductor firms have demonstrated the ability to rapidly capitalize on new technological and market opportunities, so have American computer firms pioneered

most of the design concepts that have driven information processing: networking and distributed computing, small business machines and minicomputers, time-sharing among multiple work stations, cheap mass storage, desktop microcomputers.

There are few concrete signs that this dominance by U.S.-based firms is threatened. Nevertheless, relative positions within the world computer industry will continue to shift, stimulated in many cases by new applications of computing power. As the industry continues to evolve, the technological leads of American firms are likely to shrink, and competitive positions may become more difficult to maintain. Nevertheless, the U.S. lead in worldwide marketing of data processing systems is so large that prospective challengers such as Japan cannot hope for more than modest success over the rest of the century.

2. American firms have done a much better job than their foreign competitors of balancing what the available technology can do against what customers for data processing systems have wanted to accomplish. This has been an important element in patterns of competitive success, which have depended as heavily on software that could be easily used by neophyte purchasers and was reliable—i.e., free of "bugs"—as on raw hardware performance.

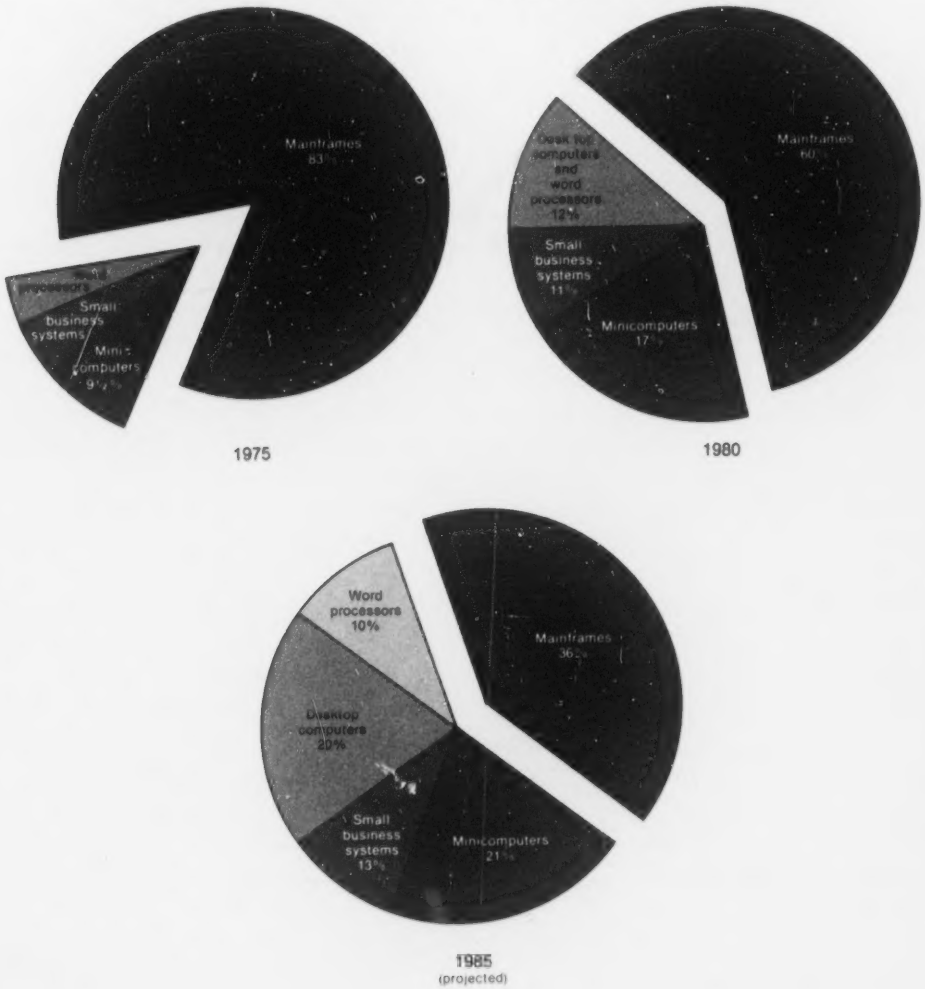
In fact, *foreign computer firms have sometimes been able to match the United States in terms of hardware;* by and large, Japan's computer manufacturers can at present. But their *systems* are still behind, mostly because the software—at all levels—is not as good. Moreover, foreign firms—whether European or Japanese—have not been as adept as Americans at finding new ways to apply their hardware. For example, U.S. firms remain well ahead in office automation, point-of-sale terminals for retail merchandisers, and many other applications of distributed intelligence.

3. The ongoing structural alterations in the data processing industry will be deeper and farther-reaching than those in microelectronics or consumer electronics.

Most of the recent technological innovations in consumer electronics have come from large, well-established firms; new products from small companies have seldom reached mass markets. In microelectronics, while start-ups have resumed in the United States—many striving to establish themselves with the aid of innovative products—the path of technological evolution seems, for the moment, well charted; there are few signs of sudden change that would seriously unsettle the industry. Computer technology—which depends on microelectronics, but also on other feeders, primarily software—is potentially more volatile. *As new applications of computing power open windows of opportunity for firms in many parts of the world, American manufacturers will face more intense competitive pressures.* Distributed intelligence will transform a broad range of other industries as well.

While the era of the mainframe computer is hardly over, the increasing importance of smaller machines—minicomputers, small business

Market Segmentation of U.S. Computer Sales by Value



SOURCE: "Moving Away From Main Frames: The Large Computer Makers' Strategy for Survival," *Business Week*, Feb. 15, 1981, p. 78.

systems, personal computers, and "smart" devices that do not even look like computers—will continue to provide the greatest opportunities for growth and expansion. The multitude of prospective applications of computing power will offer new openings for overseas firms as well as American companies. In some portions of the data processing equipment industry—especially those still in relative infancy, such as desktop machines and standardized office automation products—foreign firms may eventually achieve a greater presence than they have managed in mainframe systems or general-purpose minicomputers. To the extent that computers become mass-market products, manufacturers in other parts of the world are likely to emerge as more formidable competitors.

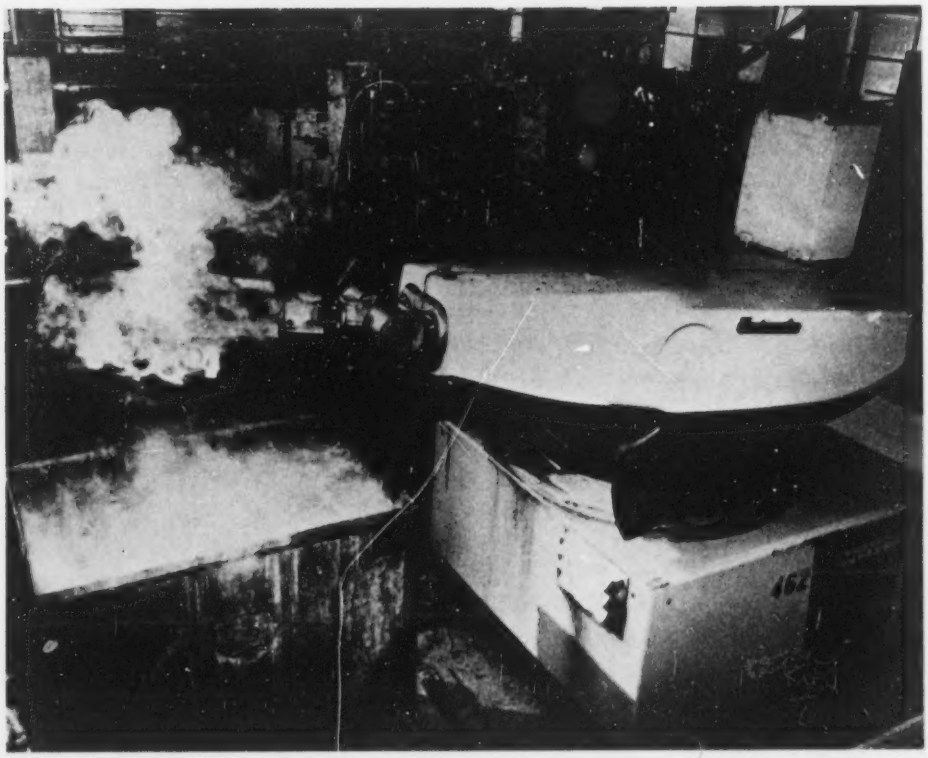


Photo credit: Unimation

Industrial robot at work

4. In the computer industry, as in microelectronics, U.S. employment is rising much less rapidly than output. *Although new jobs are being created making, operating, and maintaining "smart machines," other jobs are being destroyed; the net effects on U.S. employment might be positive or might be negative.* While there is little meaningful evidence on either side of the job creation/job destruction question, there is no question that skill requirements are changing rapidly. In some cases, automation—aided by electronics—lowers the skill requirements associated with the remaining jobs; in other cases, "upskilling" rather than "deskilling" results. A readily predictable consequence has been serious labor market dislocations; these seem bound to intensify. Even if labor market shifts cannot be predicted very well, the need for adjustment is clear. To the extent that labor market shifts—geographical, in terms of skills, in terms of wage levels—are unexpected (and some will always be), the impacts will be more severe. An obvious implication is that policy responses must emphasize flexibility.

5. Japan's computer manufacturers will not be content with narrow or specialized markets. Following strategies similar to those that have succeeded in consumer electronics and semiconductors, Japanese com-

puter firms will attempt to establish themselves in selected data processing markets and expand from there. Backed by government efforts such as the fifth-generation computer project, Japan's industry is bent on achieving technological and commercial parity (or superiority) in machines ranging from desktop processors to supercomputers. Still, Japan's rising export strength in computers differs in a major way from the patterns visible in consumer electronics or semiconductors: the leading Japanese exporter of computers, by a large margin, is IBM-Japan—despite the fact that it has been barred from many of the government programs that have aided other computer manufacturers.

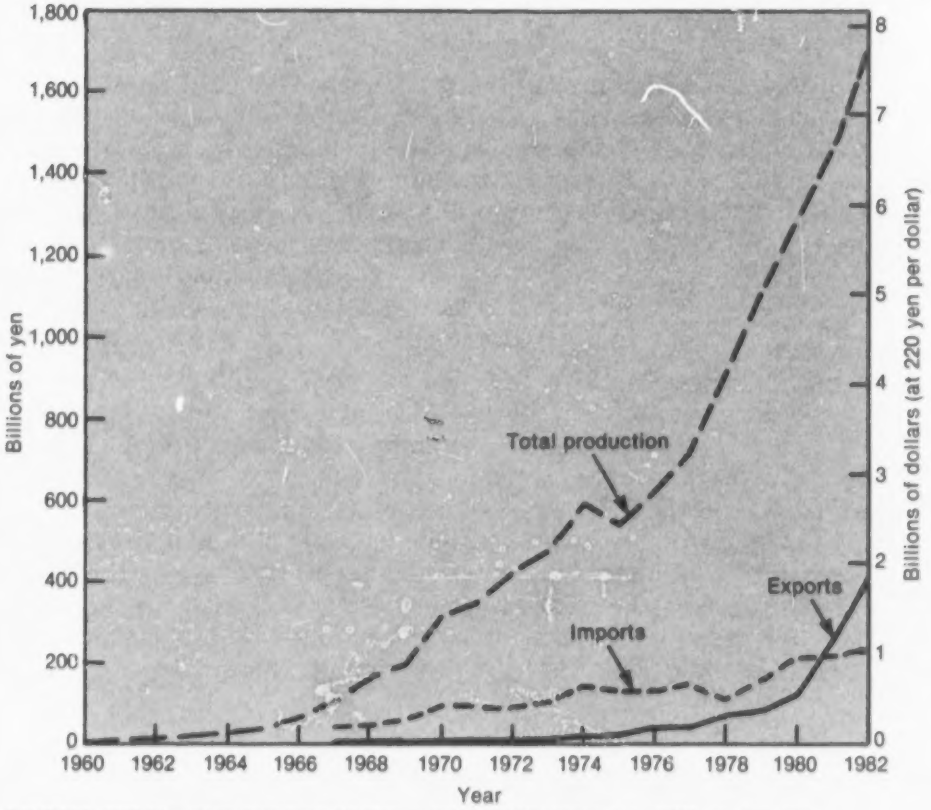
While IBM has abundant resources and technology to compete effectively against Japanese computer firms, other American manufacturers may face increasing difficulty in the future. Although the U.S. industry is not immediately imperiled, the Federal Government could help ensure future competitiveness through a better developed, more consistent industrial policy, particularly one supporting technology development and technical education.

6. As computers and their applications continue to spread through the U.S. economy, the Federal Government might act to strengthen the competitiveness of the industry both directly and indirectly:

- "Computer literacy"—the ability to effectively utilize smart machines and systems—will be a critical skill for the labor force. Education and training in fields ranging from traditional modes of quantitative thinking (arithmetic, algebra) to software engineering deserve renewed support. Congress could provide leadership as well as direct and tangible aid.
- Federal support aimed at critical bottlenecks in data processing, mostly in software, could be a vital long-term stimulus for the American industry. Productivity in software development has gone up only slowly over the years. Financing for education and training in software engineering, as well as R&D directed at computer architectures, new programing languages, and artificial intelligence appears appropriate.
- Smaller firms striving to establish themselves in the data processing equipment industry—particularly those developing software, peripherals, and innovative applications of computing power—have the same needs as do U.S. microelectronics firms: not only people with highly developed technical skills, but adequate supplies of capital for investment in R&D and production capacity and access to foreign markets.

If effectively implemented, industrial policies in support of such needs could pay vast dividends throughout the U.S. economy because of the multitude of ways in which applications of computing power can enhance the competitiveness of firms in industries of all types.

Japanese Production, Imports, and Exports of Computers and Equipment, Including Production and Exports of U.S.-Owned Subsidiaries.



SOURCES: *1967-78—Japan Fact Book '80* (Tokyo: Dempa Publications, Inc., 1980), pp. 173, 174.
1978-80—Japan Electronics Almanac 1982 (Tokyo: Dempa Publications, Inc., 1982), pp. 58, 59.
1981, 1982—Department of Commerce, Bureau of Industrial Economics.

Conclusion

A nation can never be competitive in all industries at once. Not only will some rank higher than others, but places will change over time. Economies need to adjust; adjustment brings pain and distress to firms that encounter trouble, people who lose their jobs, the communities affected. Even within an industry like electronics—in the United States, highly competitive as a whole—some parts, such as consumer electronics, face a far more problematic future than others. That such events are inevitable does not mean that at least some of the problems cannot be anticipated, and some of the distress ameliorated by Government action. Moreover, the Federal Government can take positive actions to support the development and diffusion of technology, human resources, the infrastructure that companies depend on when pursu-

ing their individual competitive strategies. Government policies can aid growing sectors, help people and institutions adapt to change. The dynamic of international competitiveness is continuous, and calls for a continuing series of policy responses.

People can and will argue endlessly about the successes and failures of industrial policies in other countries, but the primary lesson to be drawn from foreign experience is simply this: *industrial policymaking is a continuing activity of governments everywhere.* In the United States, industrial policy has been left mostly to the random play of events. Improvement is clearly possible; policymaking can be a purposeful activity characterized by learning from past experience within a framework of empirically based analysis. Developing a more effective industrial policy for the United States must begin in this spirit, while recognizing that the process is inherently political.

There is no one thing that the Federal Government can do that will make a big difference for the future competitiveness of the U.S. electronics industry, but there are many specific policy concerns that deserve attention. Only by linking and coordinating these more effectively can the United States expect to develop a coherent and forward-looking approach to industrial policy. Until the Nation begins this task, American firms will continue to find themselves at a disadvantage when facing rivals based in countries that have turned to industrial policies as a means of enhancing their own competitiveness.

NOTE: Copies of the full report, "International Competitiveness in Electronics," can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, GPO stock No. 052-003-00933-1.

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